On the Phenomenon of Drifting Subpulses

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Visiting at Univ. Of Vermont
From: NCRA, TIFR

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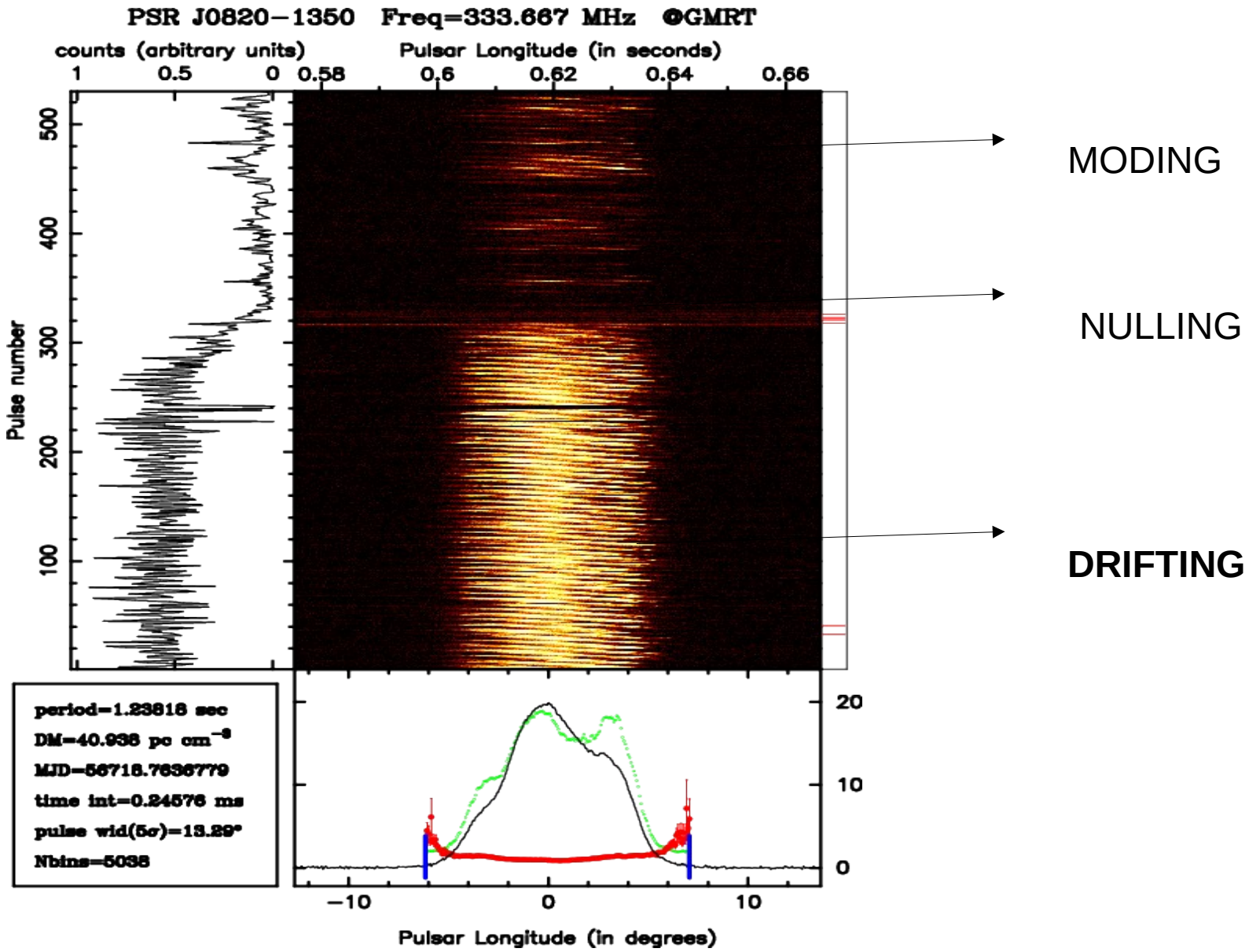
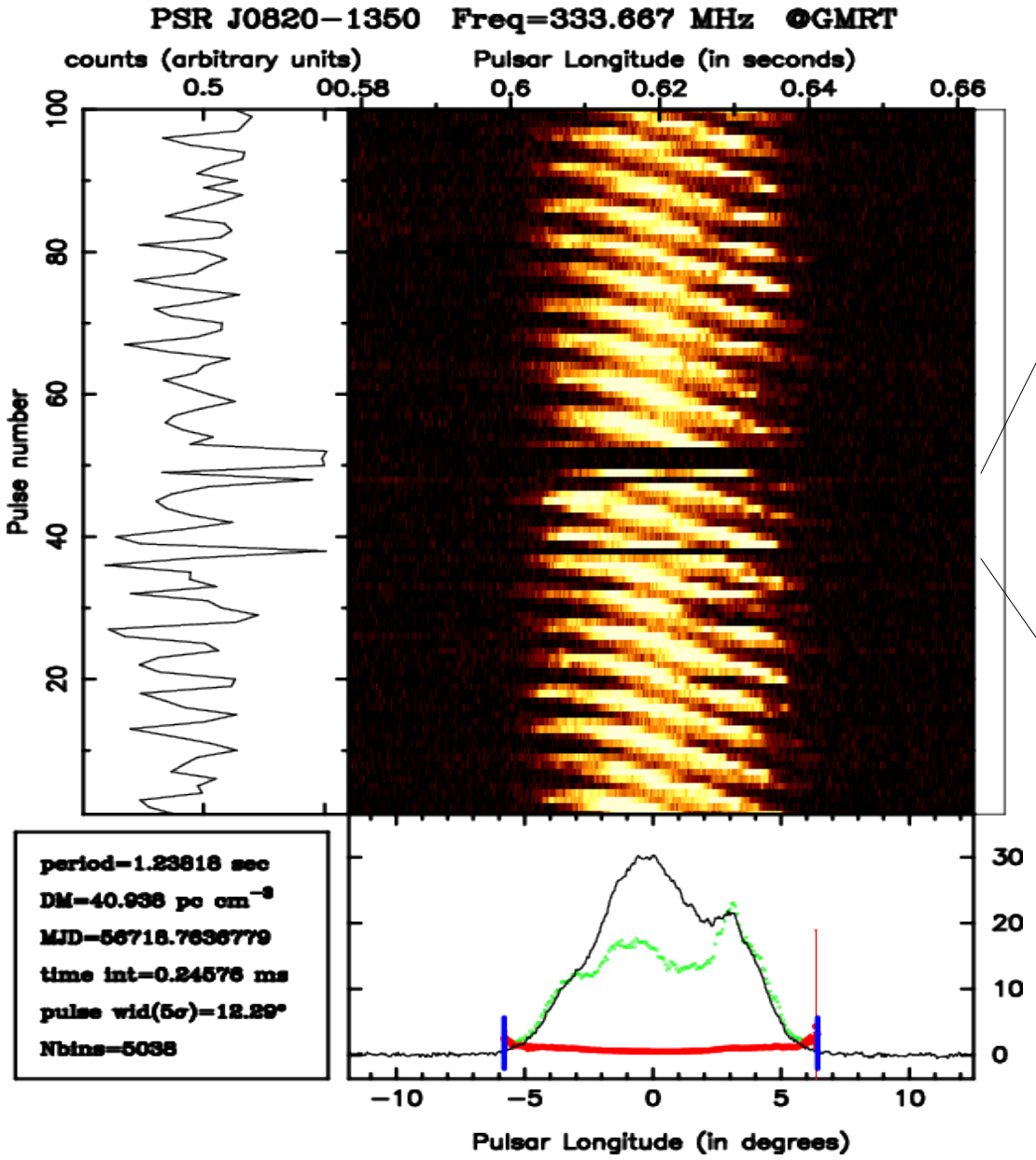
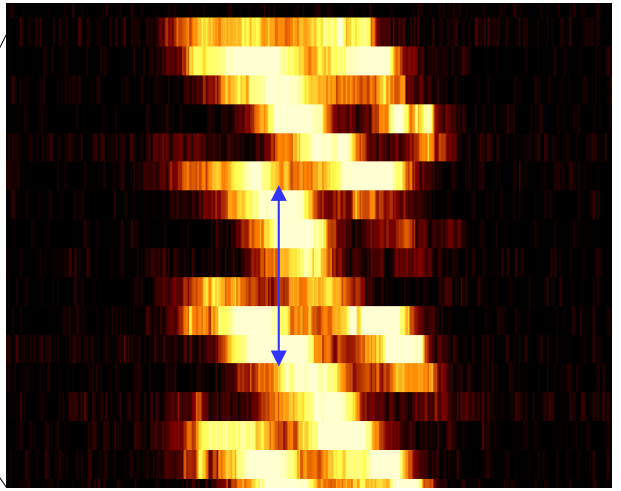
The Phenomenon



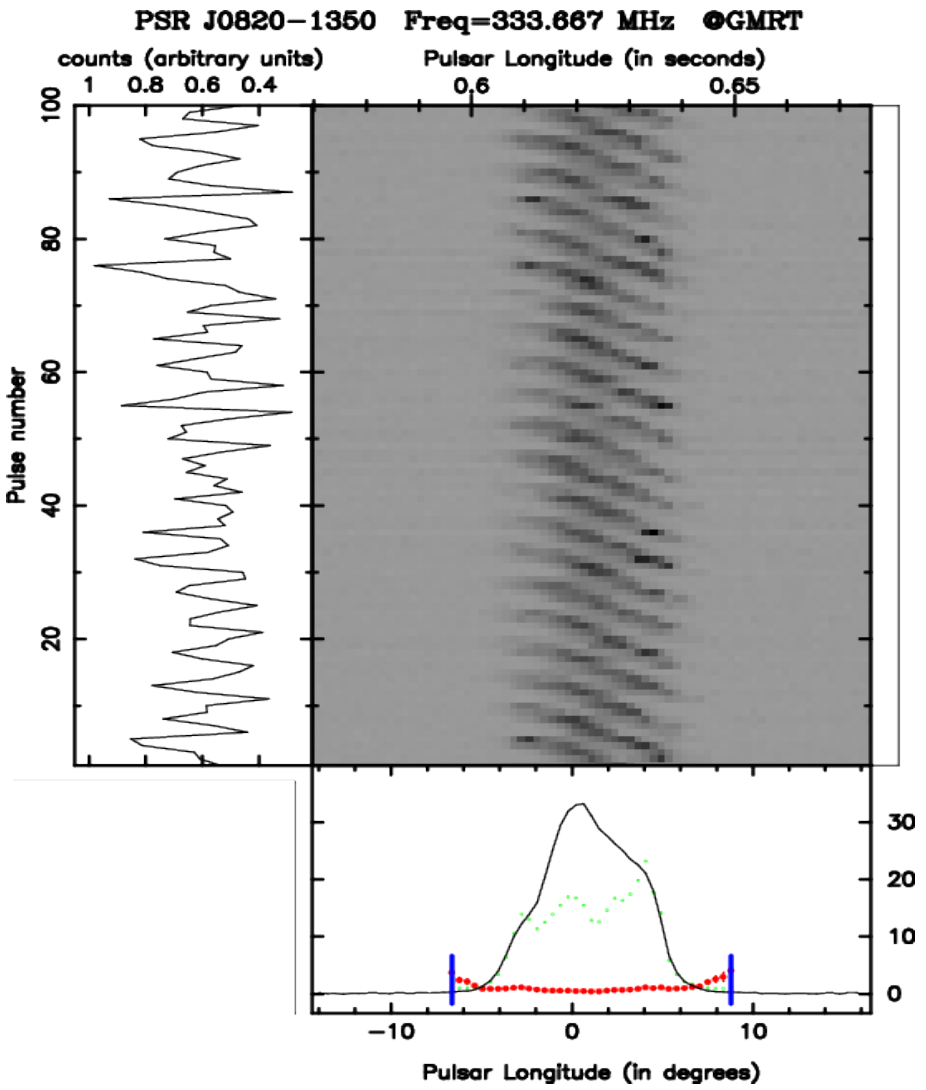
The Phenomenon

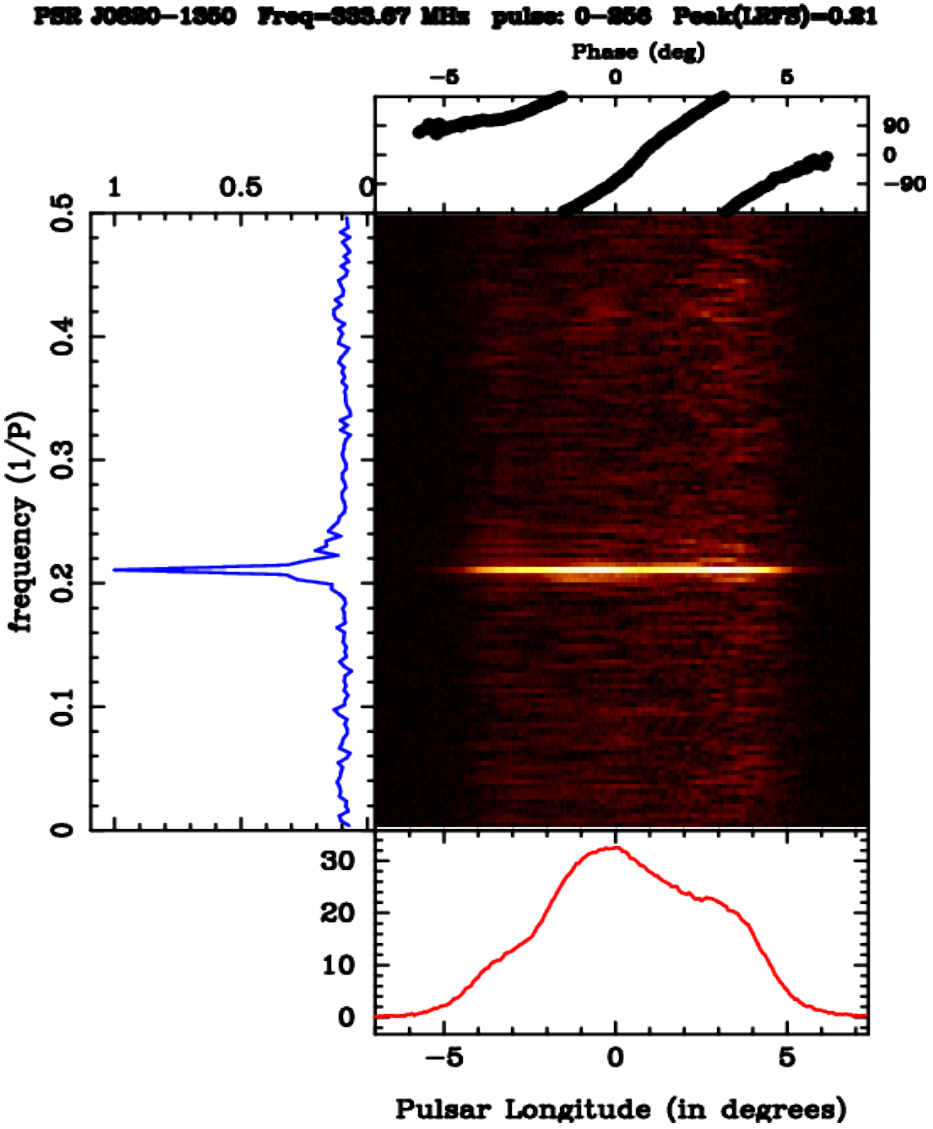




$f_3 = 1/ p_3$

Analysis Methods





Background

- Discovered by Drake & Craft (1968) and intial characterization done by Backer (1970, 1973).
- Ruderman & Sutherland (1975) proposed EXB drift to explain drifting.

- **Few Major population studies:**
- Rankin (1986): Finds drifting phenomenon is related to pulsar geometry

Weltevrede (2006, 2007): Finds around 35 % of pulsar population show drifting (using Westerbock radio telescope)

- **Major Individual pulse studies:** Deshpande & Rankin (2000), Van Leewen et al. (2003), Smits et al. (2006)

- Here we will discuss results from a recent data set of pulsars from GMRT :
- **Rahul Basu, D. Mitra, G. Melikidze, G, K Maciesiak, A Skrzypczak, A. Szary (2016)**

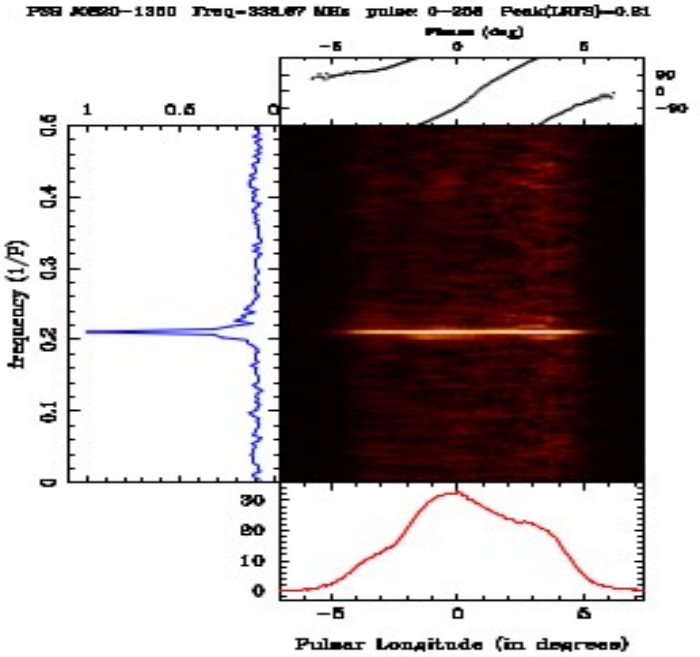
Meterwavelength Single-Pulse Polarimetric Emission Survey (MSPES)

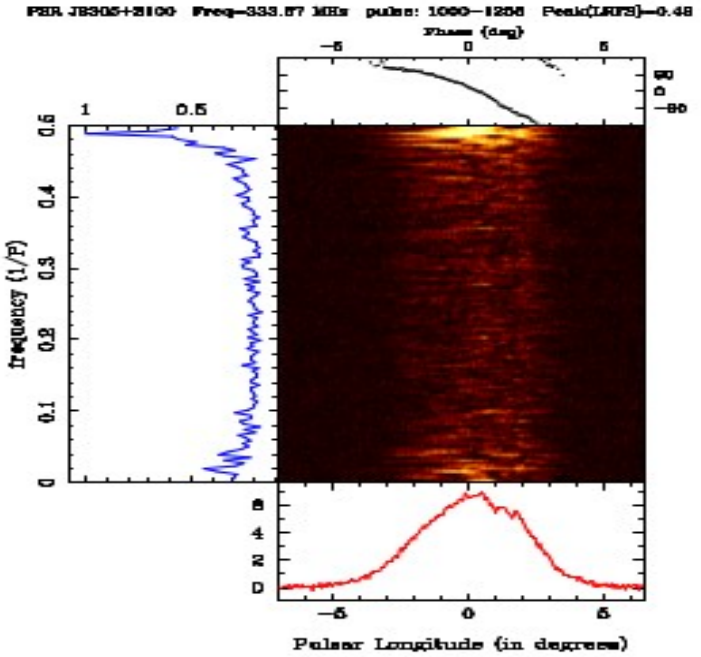
- Single pulse observations of 123 pulsars at 333 and 610 Mhz in the declination range +25 deg to -50 deg.

- 46 % pulsars showed drifting ! 22 new drifting pulsars were found.

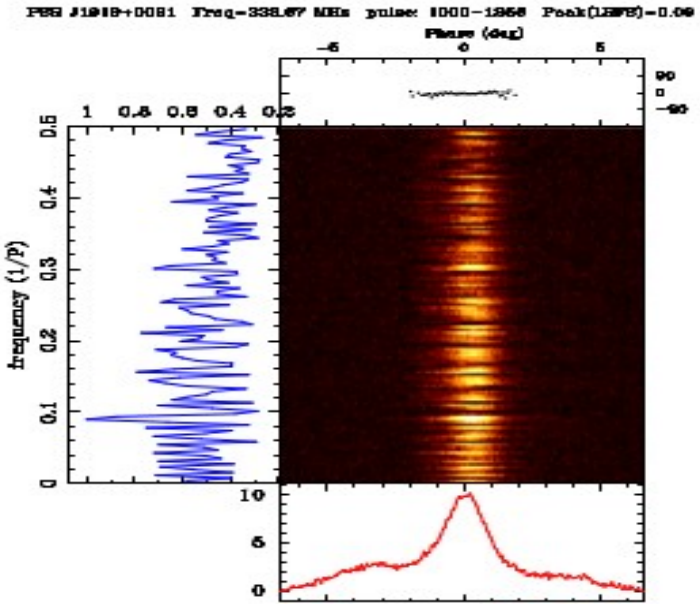
PMD: Positive Modulation Drift

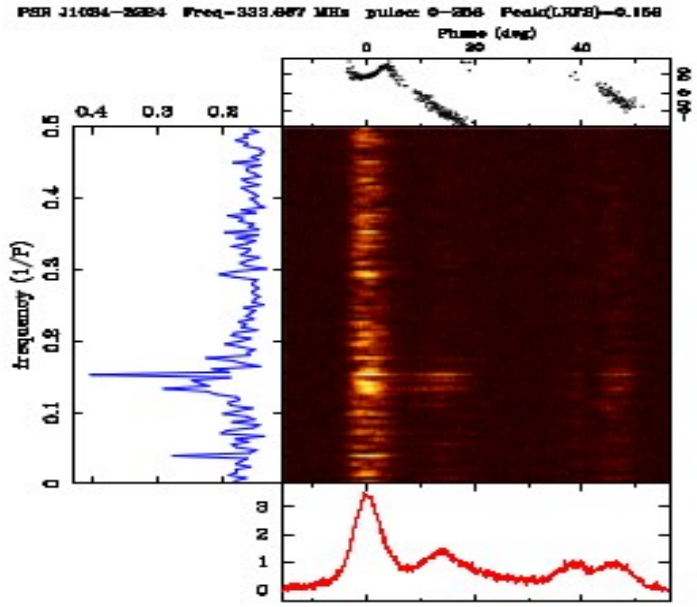
NMD: Negative Modulation Drift





AMD: Amplitue Modulation Drift



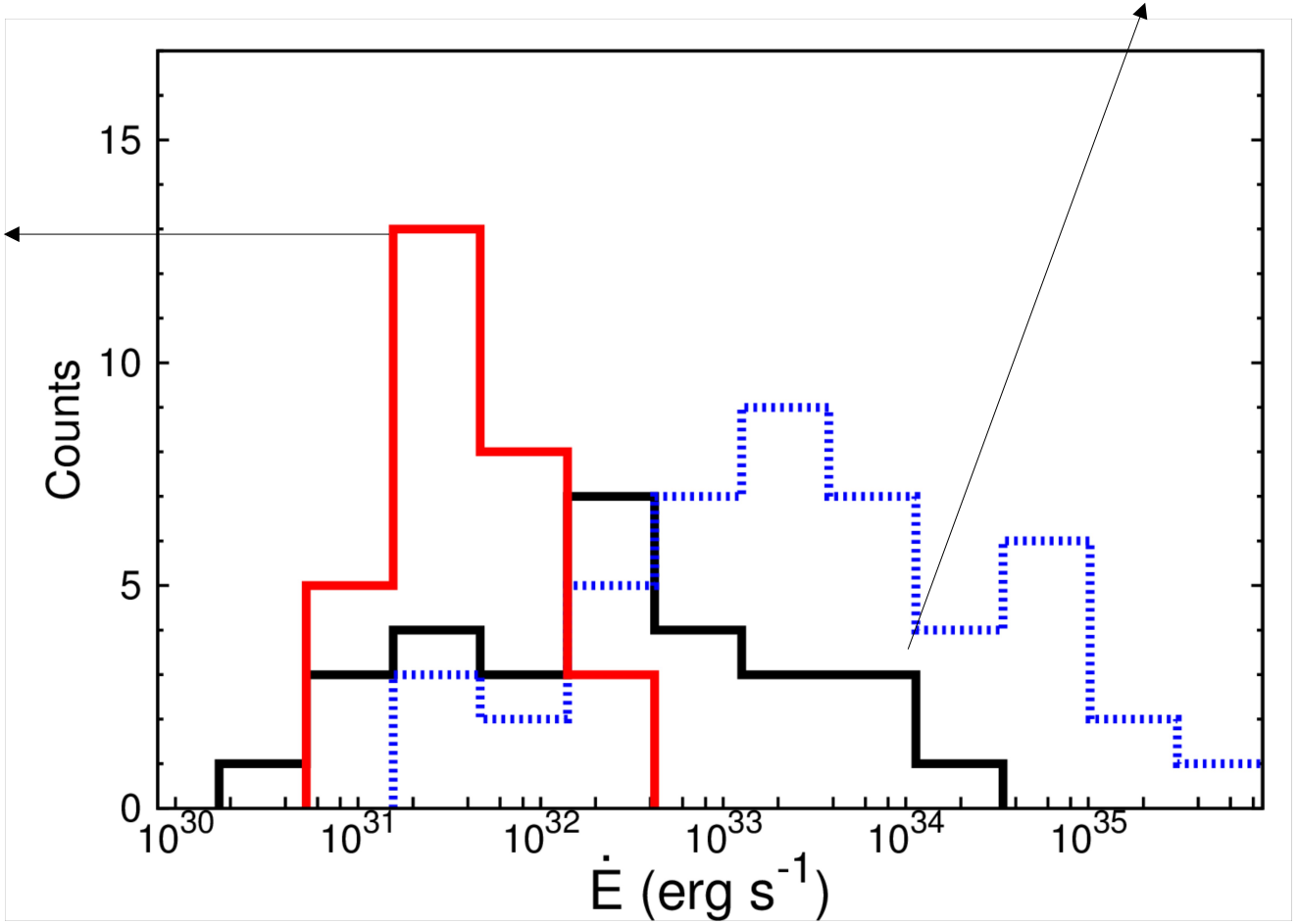


Mixed case

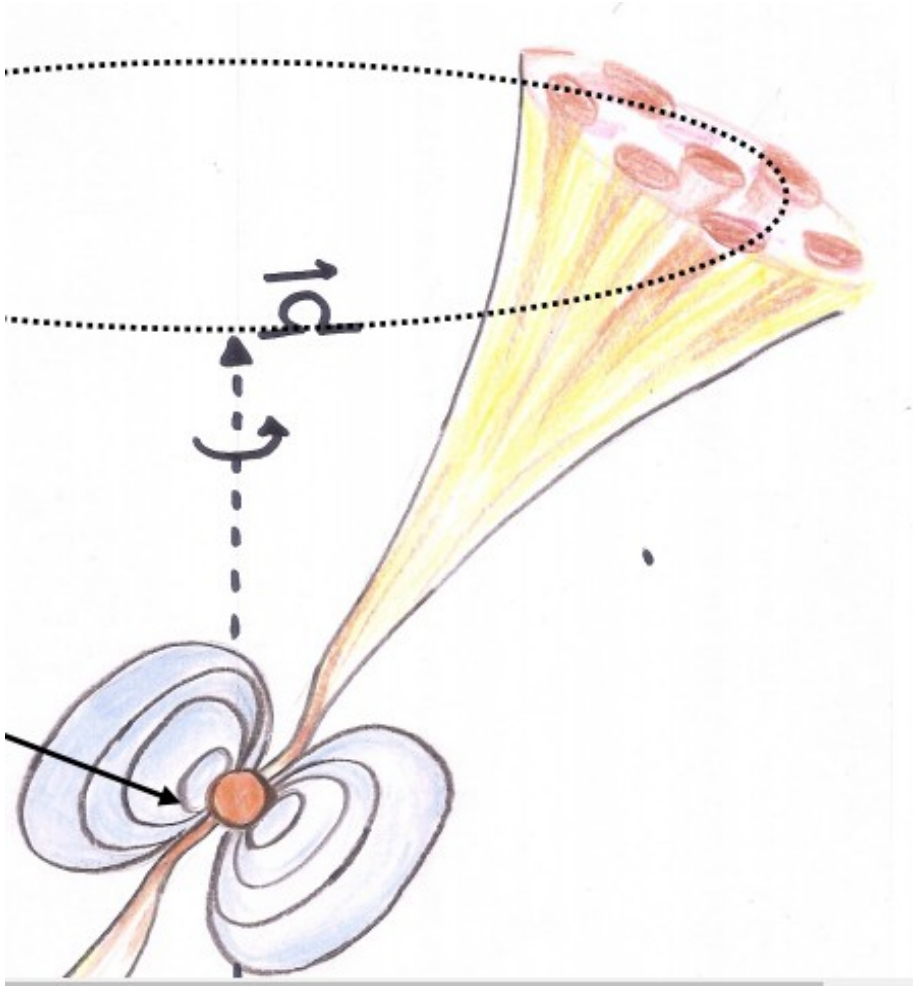
Distribution of drifting pulsars with Spindown energy

CORE SINGLE
CORE TRIPLES

CONAL DOUBLES
CONAL SINGLES
MULTIPLE



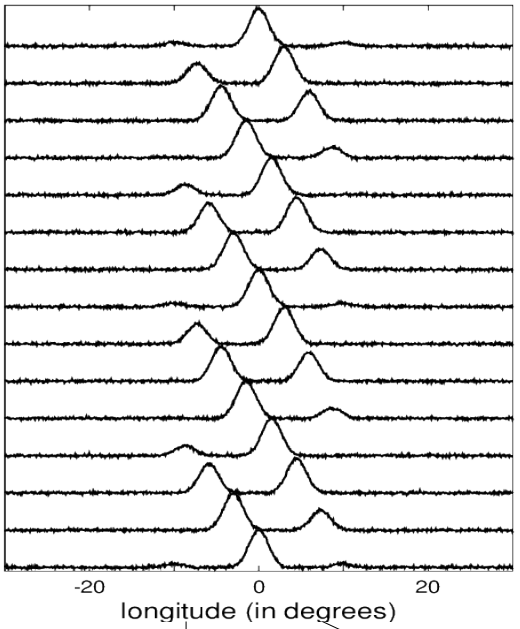
Drifting subpulses as (ΔE X B) drift

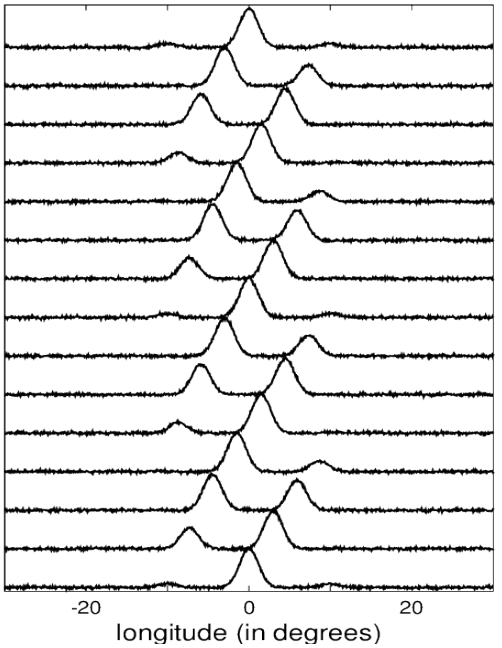


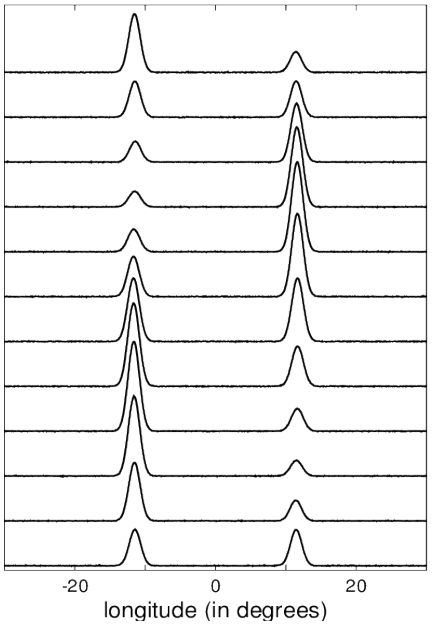
- Formation of an inner accelerating region
- Creation of localized spark associated plasma flow
- Lack of corotation leads to the drifting phenomenon

IN THIS MODEL $P_3 = 1/f_3$ IS THE TIME TAKEN FOR A SPARK TO REPEAT IN THE SAME LONGITUDE

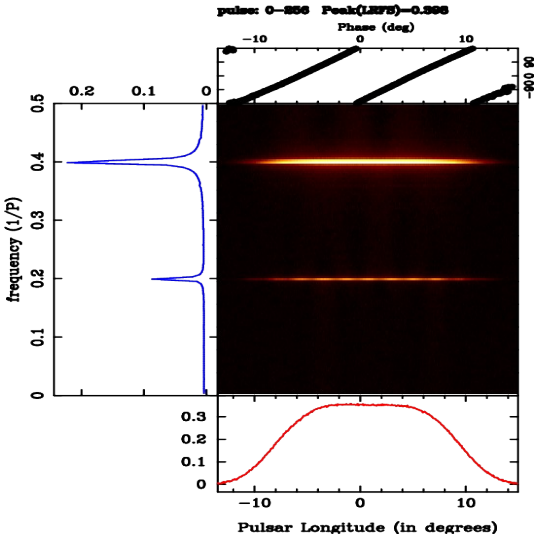
Alias Problem



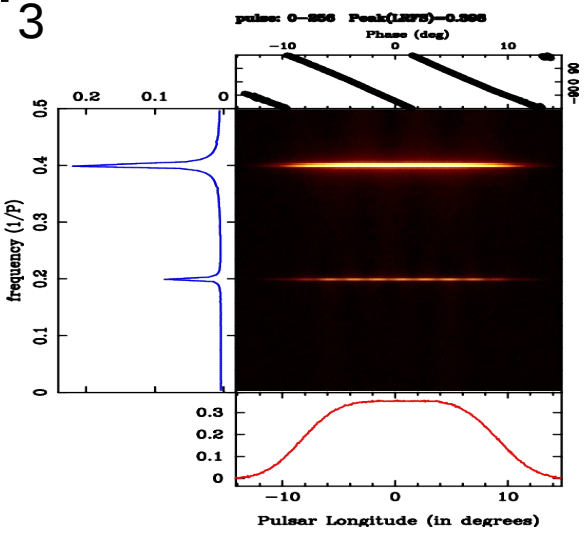


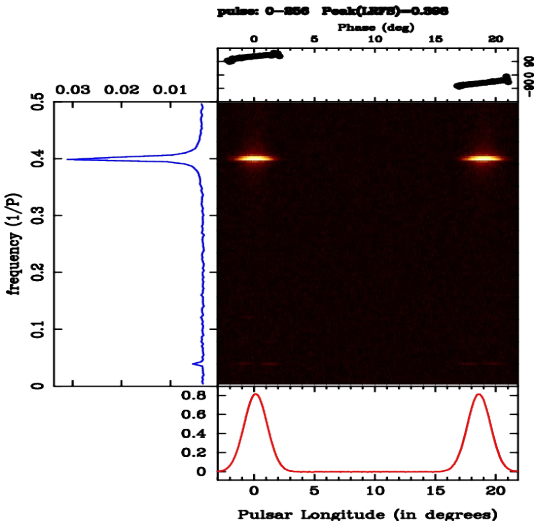


f_3



$1-f_3$

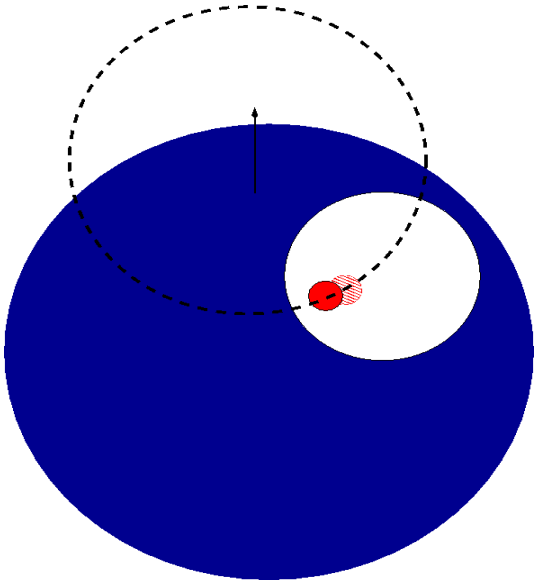


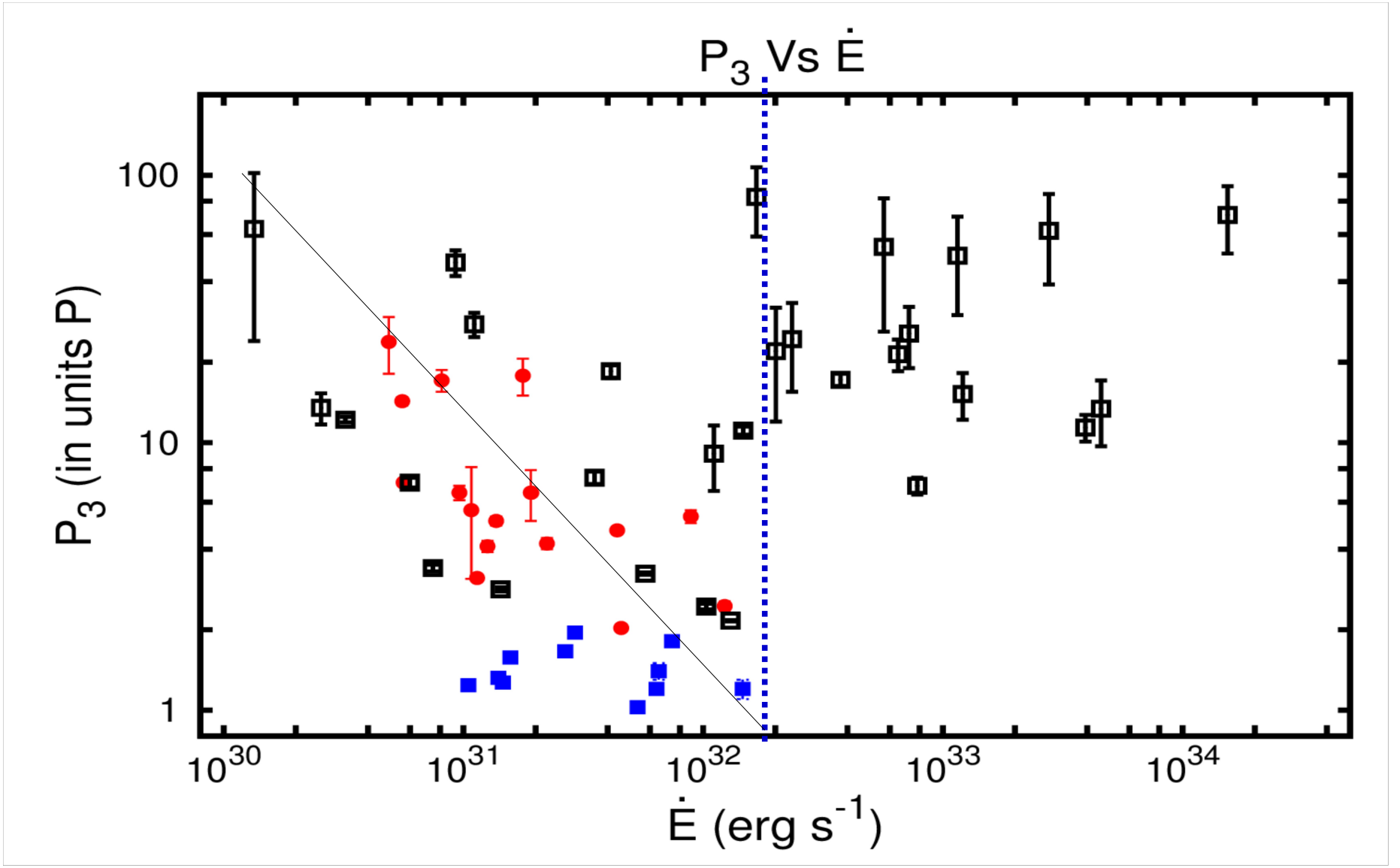


Drifting Type	1^{st} alias ($P_3 > 2P$)	2^{nd} alias ($P_3 < 2P$)
positive slope Drifting (PSD)	subpulse from trailing to leading edge	subpulse from leading to trailing edge
negative slope Drifting (NSD)	subpulse from leading to trailing edge	subpulse from trailing to leading edge
Amplitude Modulation (AMD)	line of sight at lower part of subpulse	line of sight at upper part of subpulse

The pulsar rotation direction is from the leading to the trailing edge.

A possible resolution: Plasma lags behind rotation

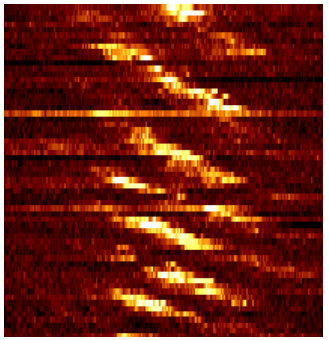




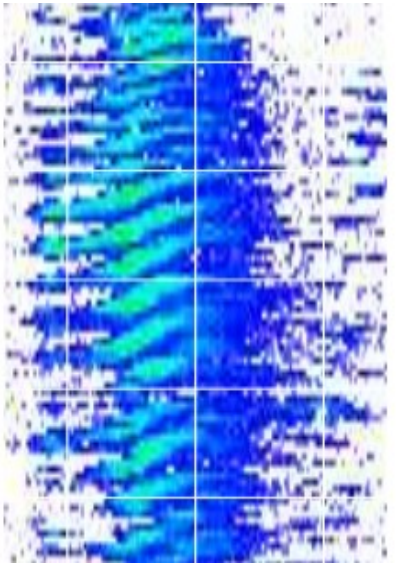
Expalining this using Partially Screened Vacuum Gap model (e.g. Gil, Geppert, Melikidze 2003)

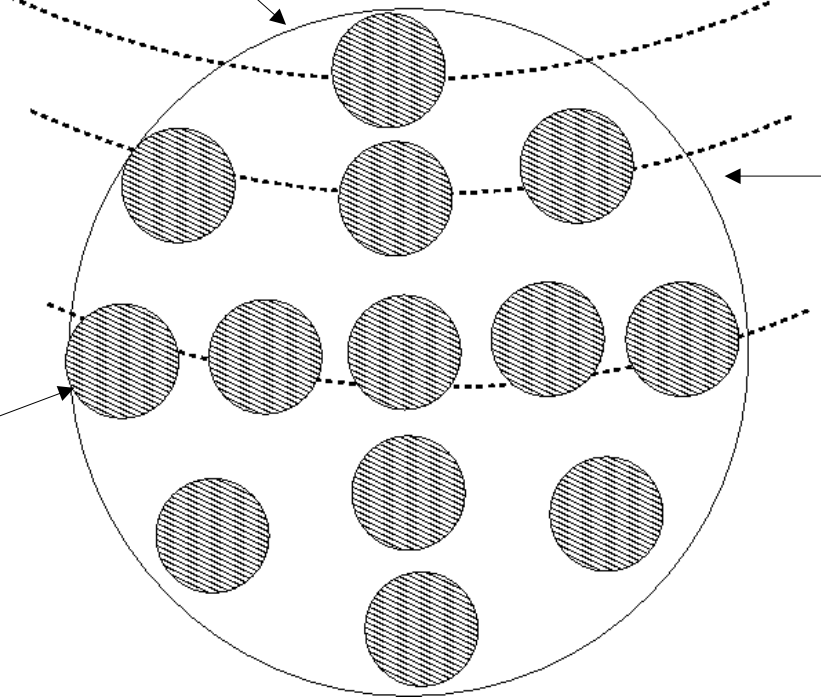
Emission Geometry and Drifting

PMD / NMD drifters
Has low inclination angle
Conal Singles and
Doubles

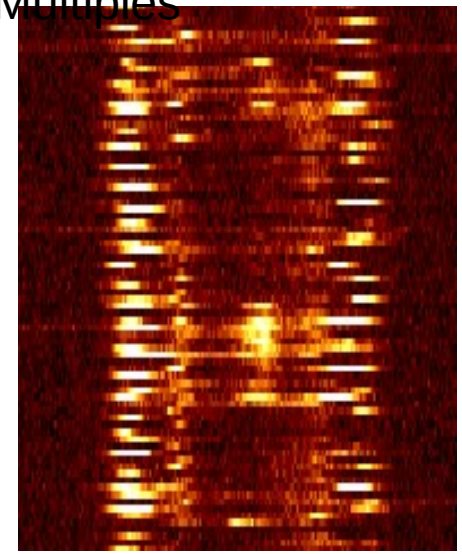


AMD and PMD/NMD
Seen in Conal Triples



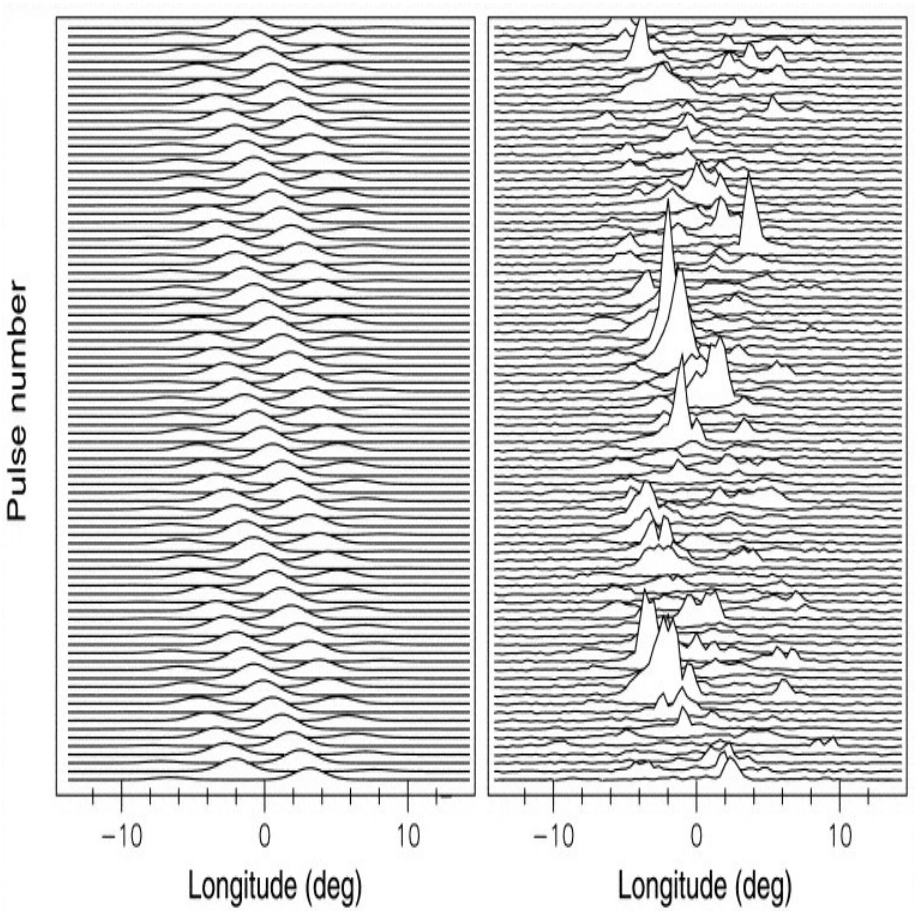


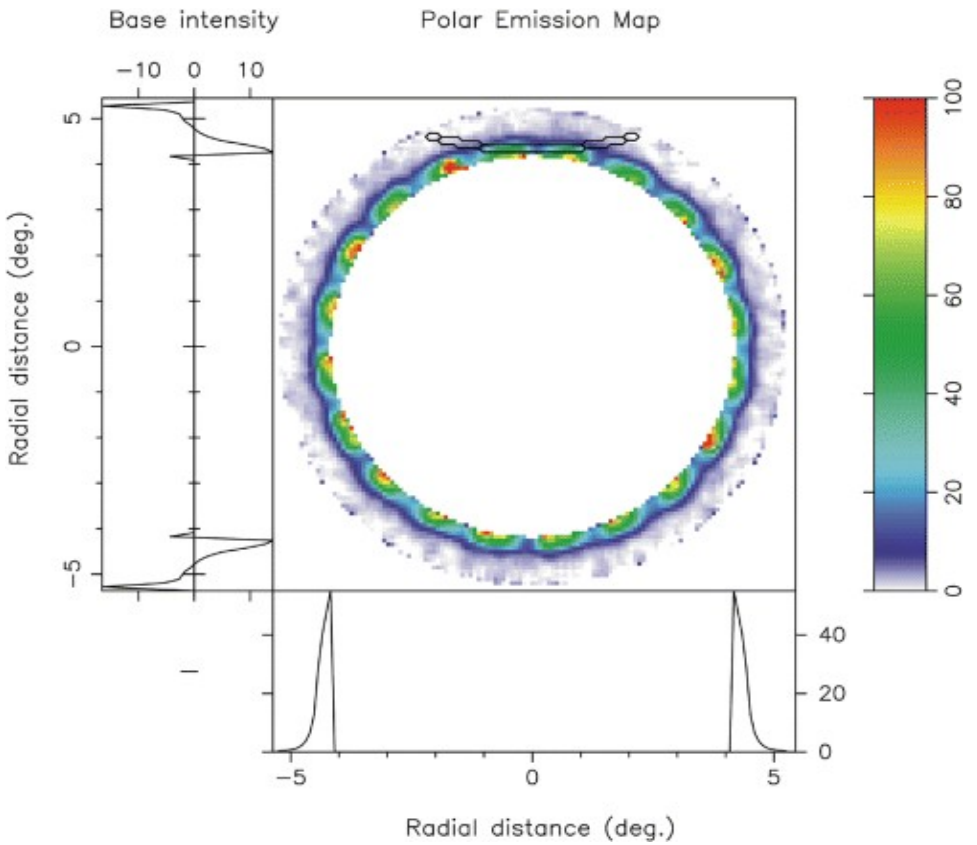
AMD: See in
Multiples



(Rankin & Wright
2013)

The Case of PSR B0943+10



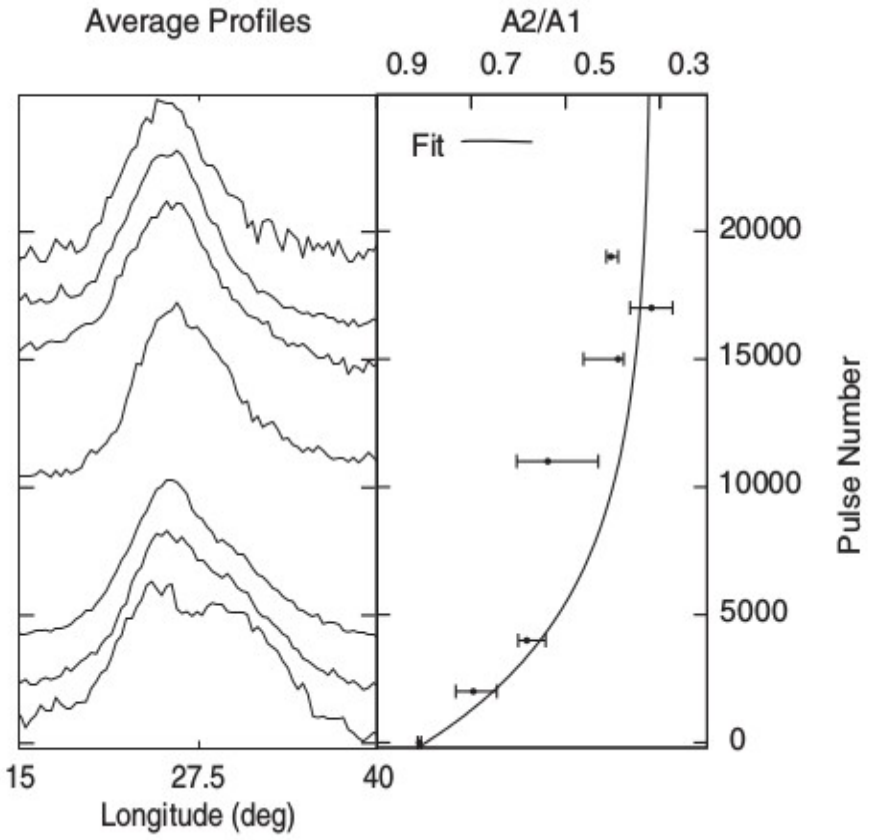


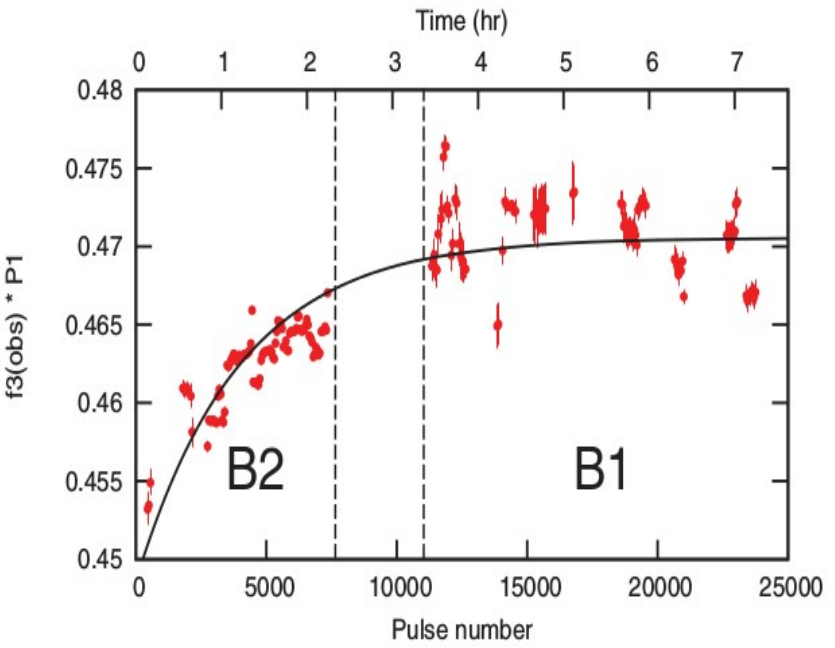
(Deshpande Rankin 99)

Explained by EXB drift of plasma (RS75)

(e.g. Deshpande and Rankin 1999, Gil & Sendyk 2000, Asgekar Deshpande Backus Mitra Rankin 2012)

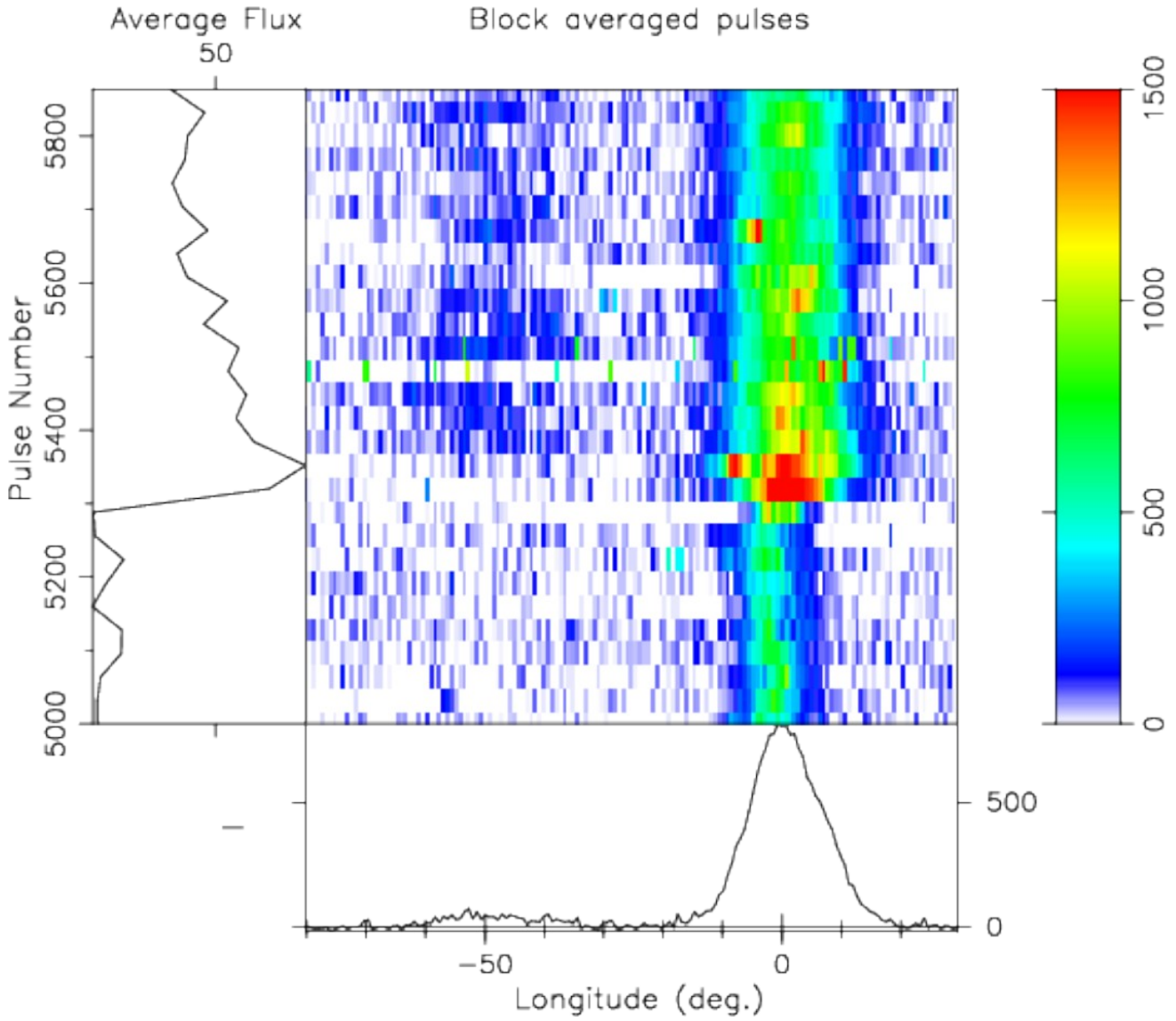
Evolution in B-mode



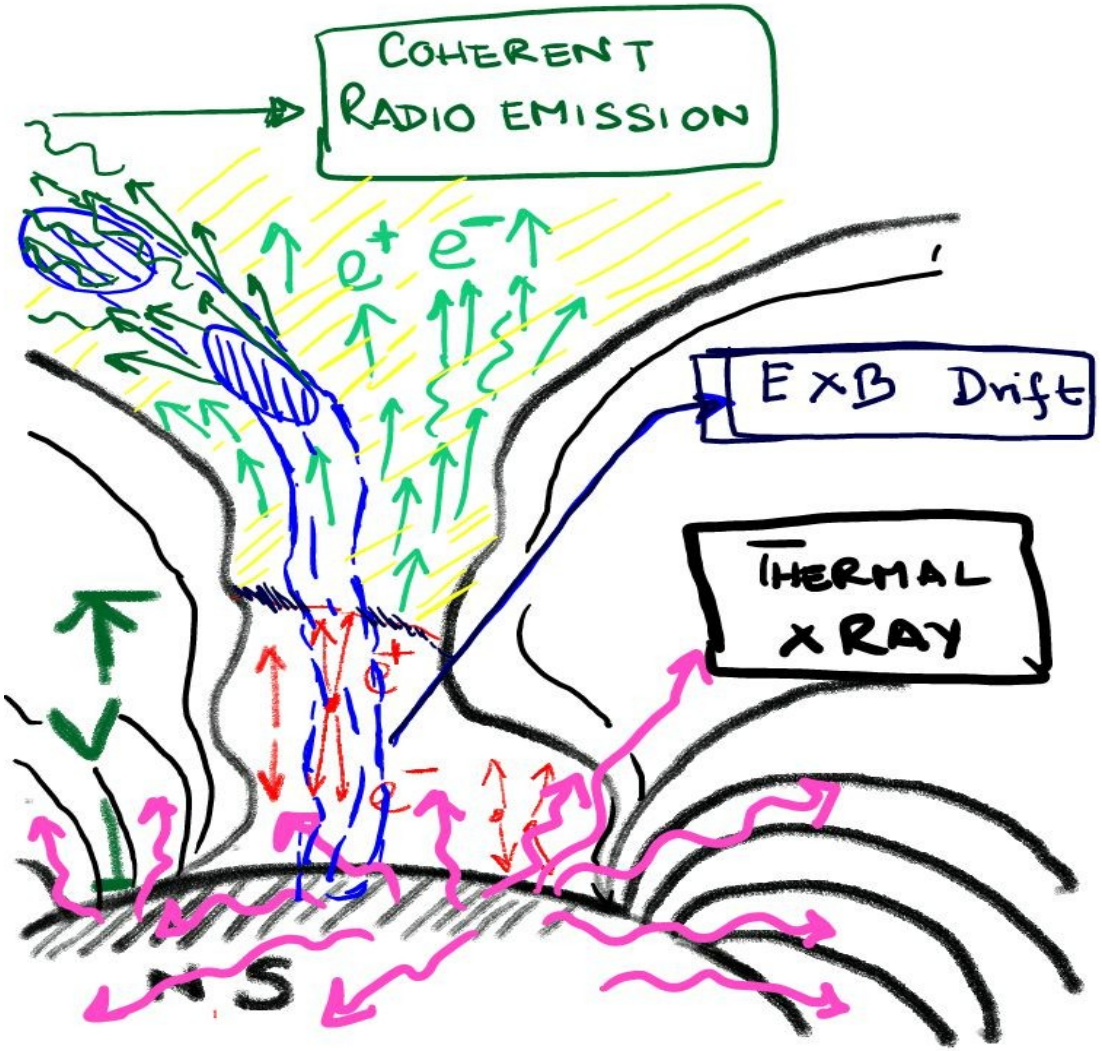


(Rankin & Suleymanova 2006,
Suleymanova & Rankin 2009,
Bilous et al. 2014
Backus Mitra Rankin 2012)

Mode changing



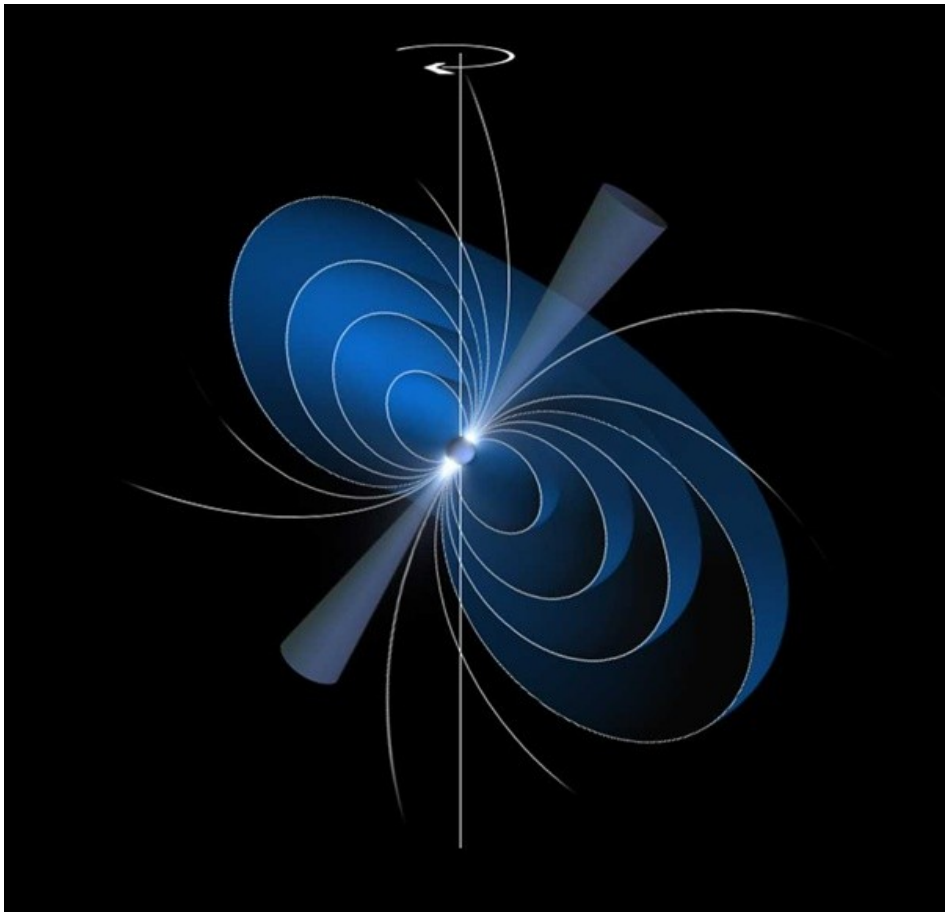
Xray/Radio emission



Evidence for Inner accelerating region

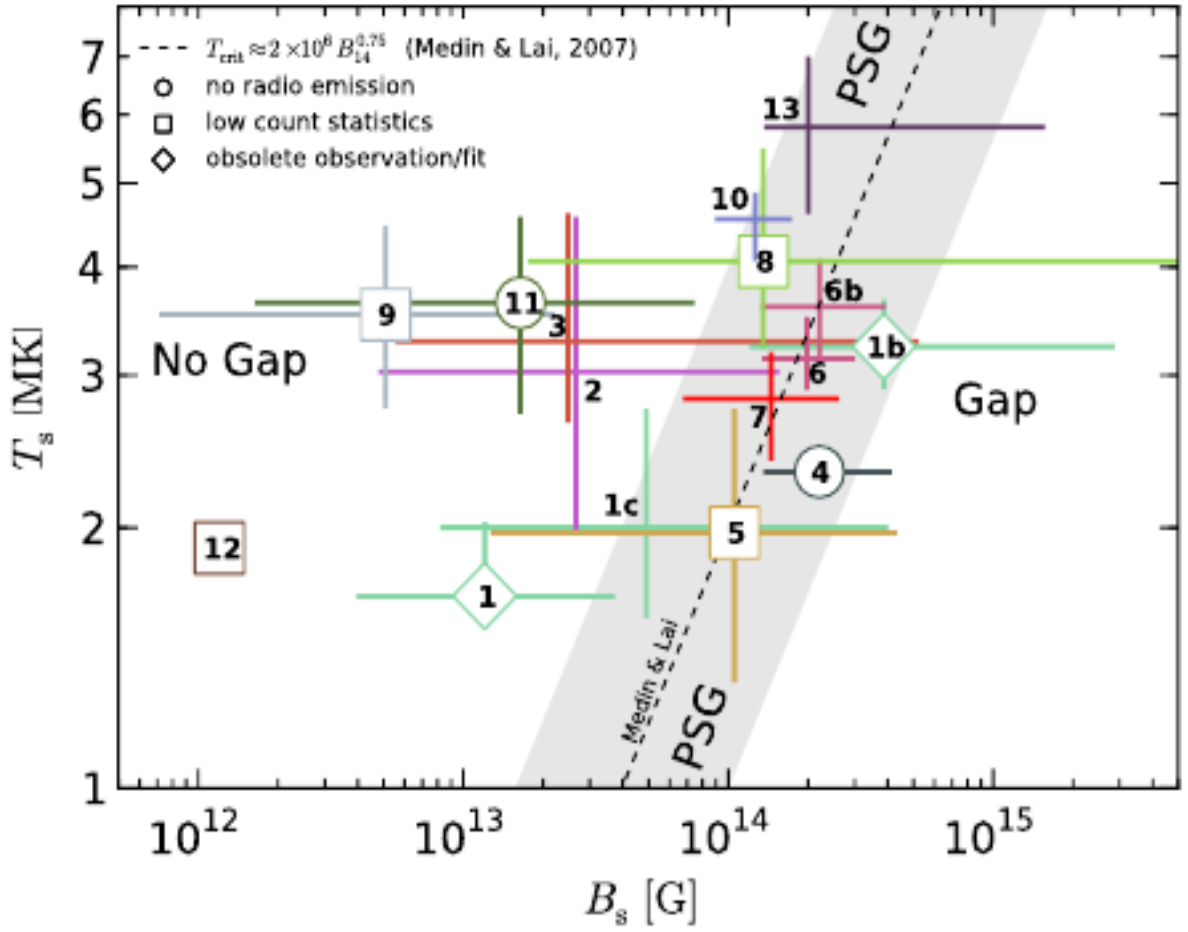
$$A = \frac{L_{xray}^{bb}}{\sigma\, T^4}$$

$$B_s = \frac{A_d}{A} B_d$$



(More on this later in W. Hermsen's talk)

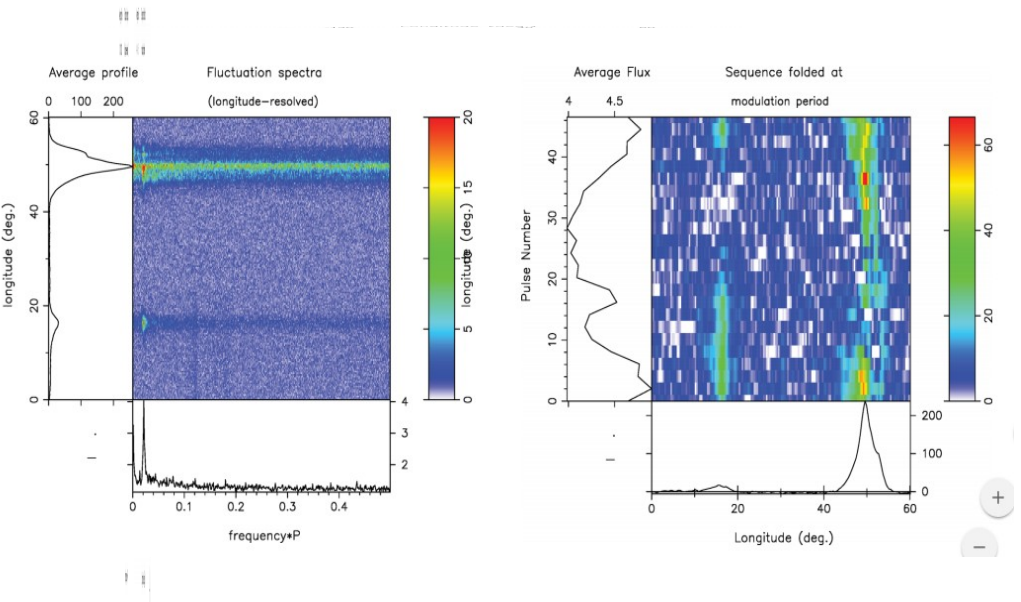
XMM and Chandra playing crucial role



(Szary et al. 2016)

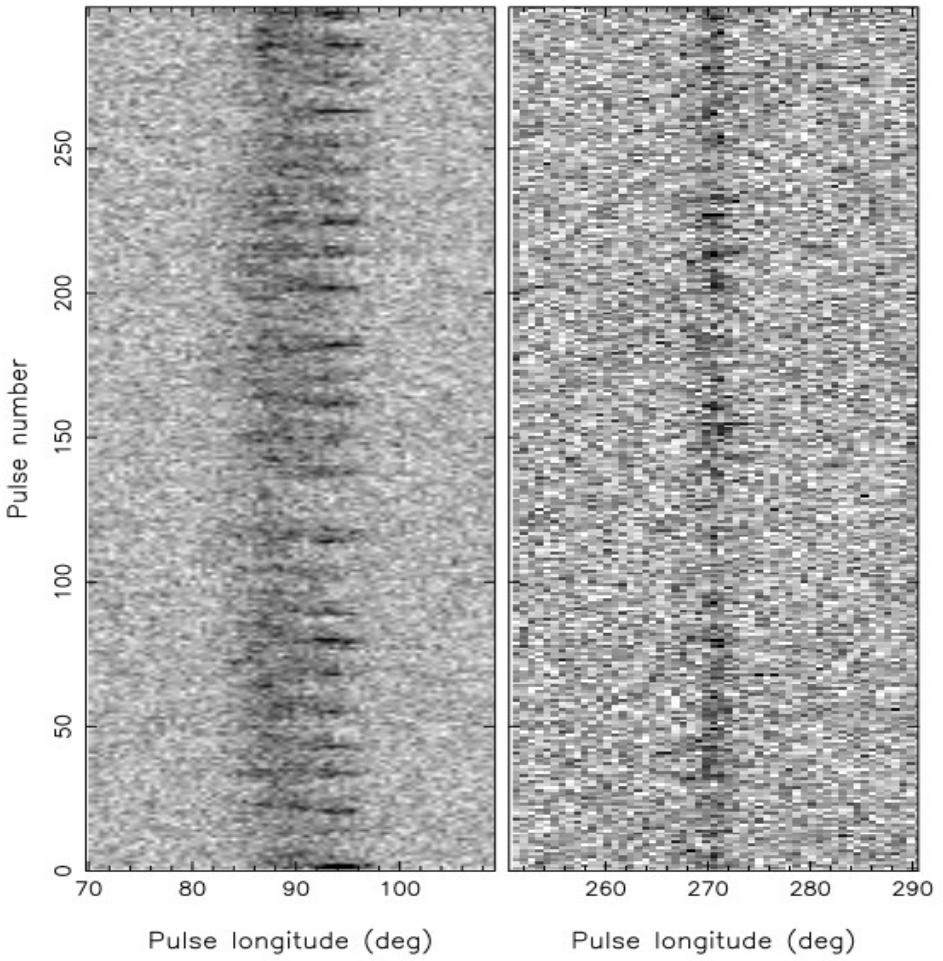
Special cases: Interpulsars

PSR B1822-09



(Backus , Mitra, Rankin 2012)

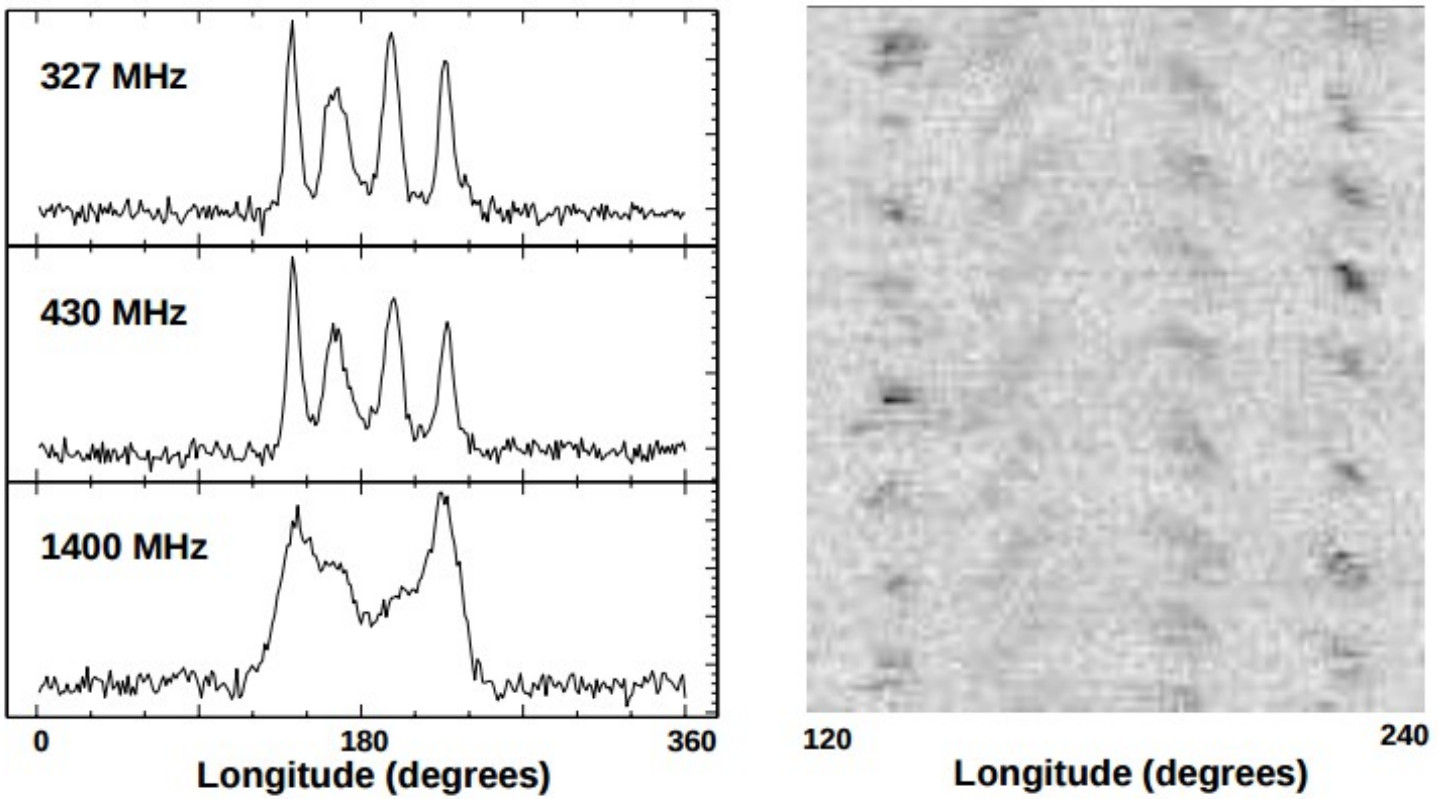
PSR B 1702-19



Weltevrede, Wright Stappers (2007)

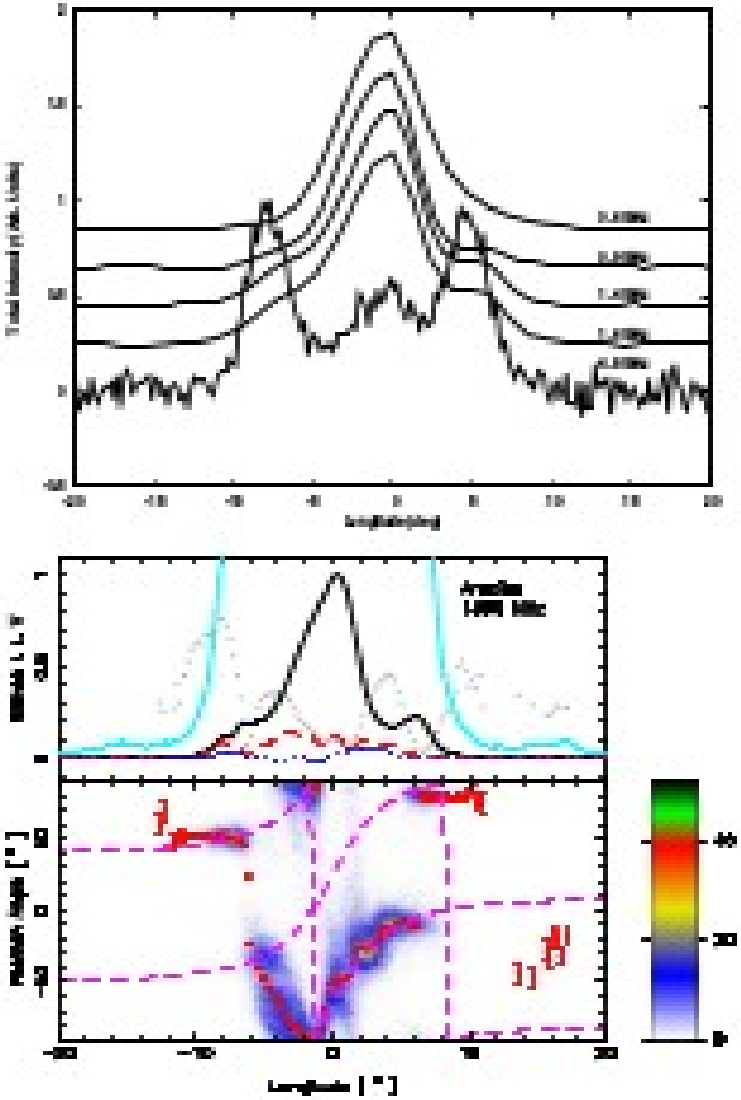
Special Case: Bi-drifting

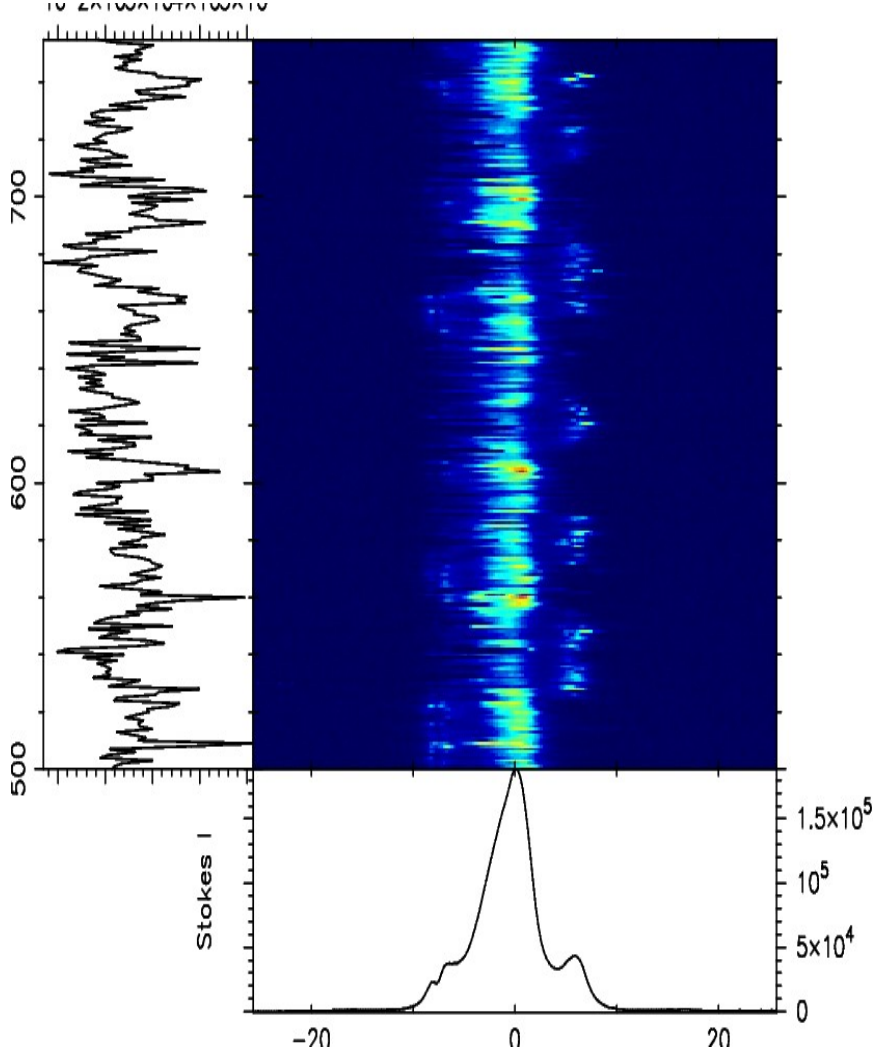
PSR J0815+09



McLaughlin et al. 2004, Discovery in Arecibo Drift Scan

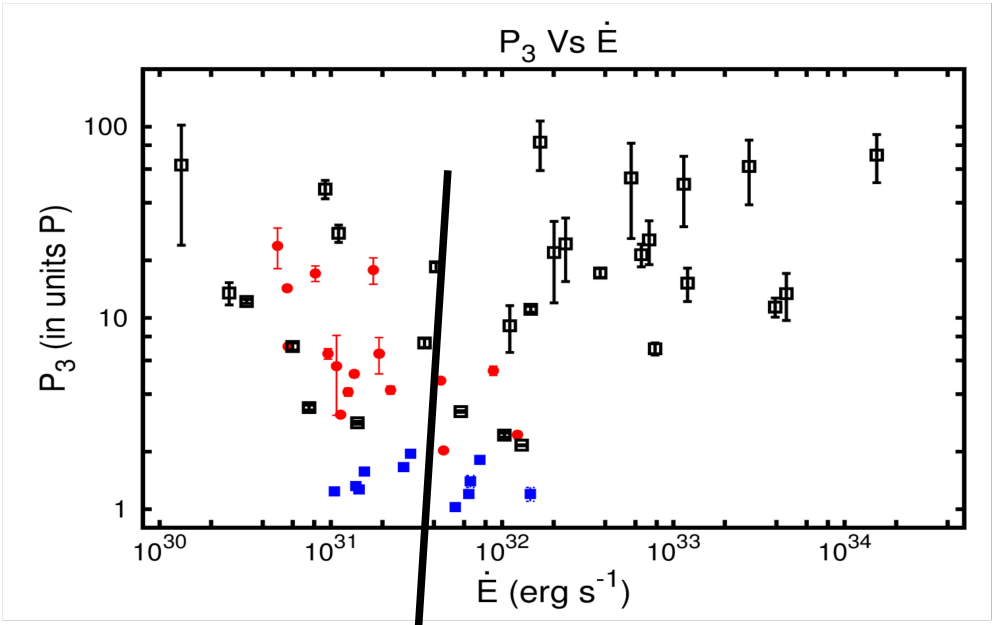
Special case: B1946+35 ! A core triple

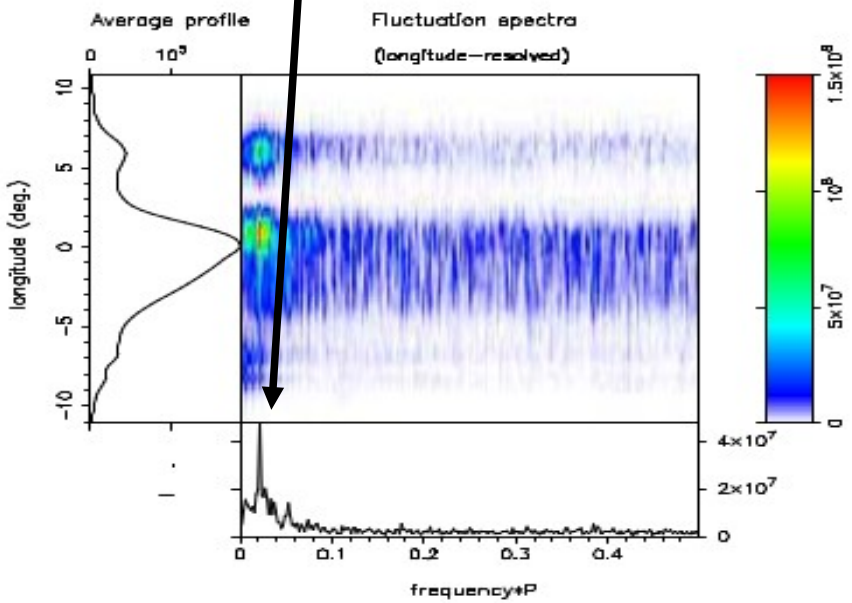


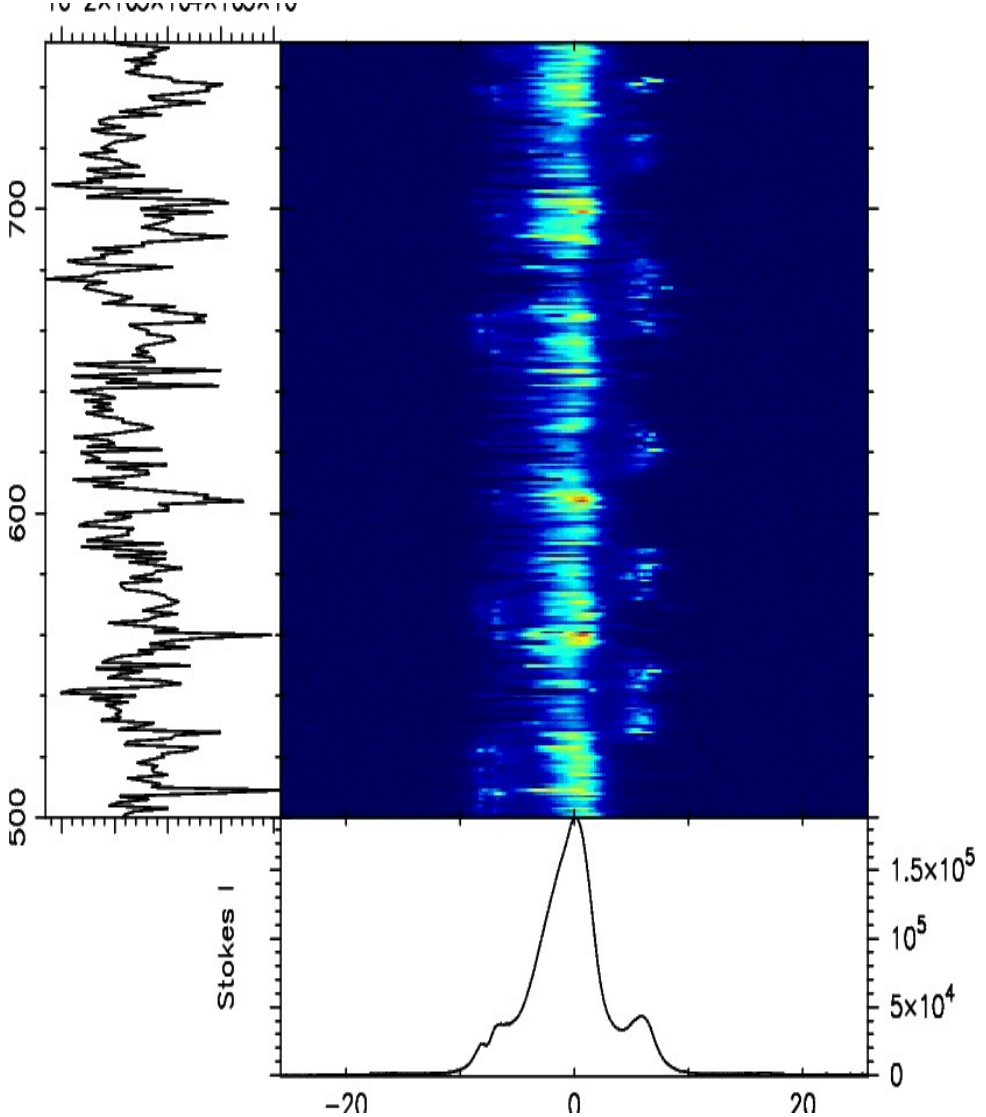


Mitra & Rankin (2016)

Periodic Moding? PSR B1946+35







Finally!

- There is both order and complexity in drifting phenomenon.
- Xray / Radio observations together is giving us more clues about the inner magnetosphere.
- What causes the phenomenon of drifting, mode changing and nulling is still unclear....

Thank you !